PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

United States Patent and Trademark Office
(Box PCT)
Crystal Plaza 2
Washington, DC 20231
ÉTATS-UNIS D'AMÉRIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 09 July 1999 (09.07.99)	
International application No. PCT/US97/19207	**Applicant's or agent's file reference** 31222-PCT
International filing date (day/month/year) 24 October 1997 (24.10.97)	**Priority date** (day/month/year)
Applicant JACOBS, Stephen et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

20 May 1999 (20.05.99)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

F. Baechler

Telephone No.: (41-22) 338.83.38

09/530085
5000

PATENT COOPERATION TREATY

REC'D 10 APR 2000
WIPO PCT

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 31222-PCT	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/US97/19207	International filing date *(day/month/year)* 24 OCTOBER 1997	Priority date *(day/month/year)* NONE
International Patent Classification (IPC) or national classification and IPC IPC(6): H04J 3/16 and US Cl.: 370/468		
Applicant THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets.

   [X] This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority. (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 5 sheets.

3. This report contains indications relating to the following items:

   - I [X] Basis of the report
   - II [ ] Priority
   - III [ ] Non-establishment of report with regard to novelty, inventive step or industrial applicability
   - IV [ ] Lack of unity of invention
   - V [X] Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI [ ] Certain documents cited
   - VII [ ] Certain defects in the international application
   - VIII [ ] Certain observations on the international application

Date of submission of the demand	Date of completion of this report
20 MAY 1999	10 MARCH 2000
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer RICKY QUOC NGO Telephone No. 703-305-4798

Form PCT/IPEA/409 (cover sheet) (July 1998)*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US97/19207

I. Basis of the report

1. With regard to the elements of the international application:*

☐ the international application as originally filed

☒ the description:
pages (See Attached), as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

☒ the claims:
pages (See Attached), as originally filed
pages _____, as amended (together with any statement) under Article 19
pages _____, filed with the demand
pages _____, filed with the letter of _____

☒ the drawings:
pages (See Attached), as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

☒ the sequence listing part of the description:
pages (See Attached), as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language _____ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in printed form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the writen sequence listing has been furnished.

4. ☒ The amendments have resulted in the cancellation of:

☒ the description, pages NONE

☒ the claims, Nos. NONE

☒ the drawings, sheets/~~fig~~ NONE

5. ☒ This report has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

** Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

***Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US97/19207

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. statement

Novelty (N)	Claims	NONE	YES
	Claims	1-36	NO
Inventive Step (IS)	Claims	NONE	YES
	Claims	1-36	NO
Industrial Applicability (IA)	Claims	1-36	YES
	Claims	NONE	NO

2. citations and explanations (Rule 70.7)

Claims 1-36 lack novelty under PCT Article 33(2) as being anticipated by Keshav, U.S. Patent No. 5,627,970.

- Regarding claims 1, 2, 11, 13, 14, 23, 25, 26 and 35, Keshav discloses a method and system for achieving and maintaining data transmission rates, same as data transmission bandwidth, between a source node and a destination node in a digital data network (see abstract). The system of Keshav includes means for maintaining an estimate of bandwidth available to from source node to the destination node (col. 6 lines 9-25); and means for adjusting transmission based on the estimate (col. 6 lines 25-31). The transmission of the system utilizes IP protocol which supports transmission in real time (col. 5 lines 48-53).

- Regarding claims 3, 15, and 27, the system of Keshav also monitors packet loss based on acknowledgements from the destination node (col. 7 line 60 to col. 8 line 5).

- Regarding claims 4, 7, 16, 19, 28, and 31, the system of Keshav also maintains a count of packets/bytes (col. 7 line 66 to col. 8 line 2).

- Regarding claims 5, 6, 8, 9, 17, 18, 20, 21, 29, 30, 32, and 33, the system of Keshav maintains the data transmission rates of how many packets/bytes are allows to be transmitted (abstract) in accordance with TCP congestion window.

- Regarding claims 10, 12, 22, 24, 34, and 36, the system of Keshav also retransmits a packet which has been determined as lost packet at the destination node (col. 8 lines 32-35).

Claims 1, 11, 13, 23, 25, and 35 lack novelty under PCT Article 33(2) as being anticipated by Gittins et al., U.S. Patent No. 5,526,350. Gittins et al. disclose system in which a bandwidth manager is arranged to dynamically allocate bandwidth to a different type of traffic in a digital telephony network (see abstract).
(Continued on Supplemental Sheet.)

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Boxes I - VIII

I. BASIS OF REPORT:

This report has been drawn on the basis of the description,
page(s) 1-13, as originally filed.
page(s) NONE, filed with the demand.
and additional amendments:
NONE

This report has been drawn on the basis of the claims,
page(s) NONE, as originally filed.
page(s) NONE, as amended under Article 19.
page(s) NONE, filed with the demand.
and additional amendments:
Pages 14-18, filed with the letter of 17 December 1999.

This report has been drawn on the basis of the drawings,
page(s) 1-4, as originally filed.
page(s) NONE, filed with the demand.
and additional amendments:
NONE

This report has been drawn on the basis of the sequence listing part of the description:
page(s) NONE, as originally filed.
pages(s) NONE, filed with the demand.
and additional amendments:
NONE

5. (Some) amendments are considered to go beyond the disclosure as filed:
NONE

V. 2. REASONED STATEMENTS - CITATIONS AND EXPLANATIONS (Continued):

Claims 1-36 meet the criteria set out in PCT Article 33(4), the system and method of claims provides data transmission between a sender and a receiver in a digital network, such system and method having industrial applicability.

——————— NEW CITATIONS ———————
NONE

Claims

1. A method for transmitting data in real time from a sender to a receiver in a digital communications network, comprising the steps of:

maintaining an estimate of bandwidth available from the sender to the receiver; and

adjusting transmission based on the estimate in order to maintain real time transmission.

2. The method according to claim 1, wherein the data comprises compressed video data.

3. The method according to claim 1, wherein maintaining the estimate of bandwidth comprises monitoring of packet loss based on acknowledgments from the receiver.

4. The method according to claim 1, wherein, in maintaining the estimate of bandwidth, the sender maintains a count of packets outstanding.

5. The method according to claim 4, wherein, in maintaining the estimate of bandwidth, the sender maintains current an upper bound on how many packets are allowed to be outstanding.

6. The method according to claim 5, wherein the upper bound is as specified by the TCP congestion window.

7. The method according to claim 1, wherein, in maintaining the estimate of bandwidth, the sender maintains a count of bytes outstanding.

8. The method according to claim 7, wherein, in maintaining the estimate of bandwidth, the sender maintains current an upper bound on how many bytes are allowed to be outstanding.

9. The method according to claim 8, wherein the upper bound is as specified by the TCP congestion window.

10. The method according to claim 1, further comprising retransmitting a packet which has been determined by the receiver as having been lost in transmission or received with an error.

11. The method according to claim 1, further comprising adapting bandwidth required by the data.

12. The method according to claim 1, further comprising discriminating between packets lost due to congestion in the network and packets received with at least one bit error.

13. A system for transmitting data in real time from a sender to a receiver in a digital communications network, comprising:

means for maintaining an estimate of bandwidth available from the sender to the receiver; and

means for adjusting transmission based on the estimate in order to maintain real time transmission.

14. The system according to claim 13, wherein the data comprises compressed video data.

15. The system according to claim 13, wherein the means for maintaining the estimate of bandwidth comprises means for monitoring of packet loss based on acknowledgments from the receiver.

16. The system according to claim 13, wherein the means for maintaining the estimate of bandwidth comprises means for maintaining a count of packets outstanding.

17. The system according to claim 16, wherein the means for maintaining the estimate of bandwidth comprises means for maintaining current an upper bound on how many packets are allowed to be outstanding.

18. The system according to claim 17, wherein the upper bound is as specified by the TCP congestion window.

19. The system according to claim 13, wherein the means for maintaining the estimate of bandwidth comprises means for maintaining a count of bytes outstanding.

20. The system according to claim 19, wherein the means for maintaining the estimate of bandwidth comprises means for maintaining current an upper bound on how many bytes are allowed to be outstanding.

21. The system according to claim 20, wherein the upper bound is as specified by the TCP congestion window.

22. The system according to claim 13, further comprising means for retransmitting a packet which has been determined by the receiver as having been lost in transmission or received with an error.

23. The system according to claim 13, further comprising means for adapting bandwidth required by the data.

24. The system according to claim 13, further comprising means for discriminating between packets lost due to congestion in the network and packets received with at least one bit error.

25. A system for transmitting data in real time from a sender to a receiver in a digital communications network, comprising a processor which is instructed for:

maintaining an estimate of bandwidth available from the sender to the receiver; and

adjusting transmission based on the estimate in order to maintain real time transmission.

26. The system according to claim 25, wherein the data comprises compressed video data.

27. The system according to claim 25, wherein maintaining the estimate of bandwidth comprises monitoring of packet loss based on acknowledgments from the receiver.

28. The system according to claim 25, wherein, in maintaining the estimate of bandwidth, the sender maintains a count of packets outstanding.

29. The system according to claim 28, wherein, in maintaining the estimate of bandwidth, the sender maintains current an upper bound on how many packets are allowed to be outstanding.

30. The system according to claim 29, wherein the upper bound is as specified by the TCP congestion window.

31. The system according to claim 25, wherein, in maintaining the estimate of bandwidth, the sender maintains a count of bytes outstanding.

32. The system according to claim 31, wherein, in maintaining the estimate of bandwidth, the sender maintains current an upper bound on how many bytes are allowed to be outstanding.

33. The system according to claim 32, wherein the upper bound is as specified by the TCP congestion window.

34. The system according to claim 25, wherein the processor is instructed further for retransmitting a packet which has been determined by the receiver as having been lost in transmission or received with an error.

35. The system according to claim 25, wherein the processor is instructed further for adapting bandwidth required by the data.

36. The system according to claim 25, wherein the processor is instructed further for discriminating between packets lost due to congestion in the network and packets received with at least one bit error.

PCT/US97/19207

31222 PCT

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF RECEIPT OF RECORD COPY

(PCT Rule 24.2(a))

To:

1997 DEC 23 A 11:30

TANG, Henry
Brumbaugh, Graves, Donohue & Raymond
30 Rockefeller Plaza
New York, NY 10112-0228
ETATS-UNIS D'AMERIQUE

Date of mailing (day/month/year)	IMPORTANT NOTIFICATION
10 December 1997 (10.12.97)	
Applicant's or agent's file reference	**International application No.**
31222-PCT	PCT/US97/19207

The applicant is hereby notified that the International Bureau has received the record copy of the international application as detailed below.

Name(s) of the applicant(s) and State(s) for which they are applicants:

THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK (for all designated States except US)
JACOBS, Stephen et al (for US)

International filing date	:	24 October 1997 (24.10.97)
Priority date(s) claimed	:	
Date of receipt of the record copy by the International Bureau	:	09 December 1997 (09.12.97)
List of designated Offices	:	

National :CA,US

ATTENTION

The applicant should carefully check the data appearing in this Notification. In case of any discrepancy between these data and the indications in the international application, the applicant should immediately inform the International Bureau.

In addition, the applicant's attention is drawn to the information contained in the Annex, relating to:

- [X] time limits for entry into the national phase;
- [X] confirmation of precautionary designations;
- [ ] requirements regarding priority documents.

A copy of this Notification is being sent to the receiving Office and to the International Searching Authority.

ON DOCKET FOR
1/24/99 - Precautionary Desig
6/24/99 - Deadline

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer: I. Britel
Facsimile No. (41-22) 740.14.35	Telephone No. (41-22) 338.83.38

Form PCT/IB/301 (September 1996)

001800542

INFORMATION ON TIME LIMITS FOR ENTERING THE NATIONAL PHASE

The applicant is reminded that the "national phase" must be entered before each of the designated Offices indicated in the Notification of Receipt of Record Copy (Form PCT/IB/301) by paying national fees and furnishing translations, as prescribed by the applicable national laws.

The time limit for performing these procedural acts is **20 MONTHS** from the priority date or, for those designated States which the applicant elects in a demand for international preliminary examination or in a later election, **30 MONTHS** from the priority date, provided that the election is made before the expiration of 19 months from the priority date. Some designated (or elected) Offices have fixed time limits which expire even later than 20 or 30 months from the priority date. In other Offices an extension of time or grace period, in some cases upon payment of an additional fee, is available.

In addition to these procedural acts, the applicant may also have to comply with other special requirements applicable in certain Offices. **It is the applicant's responsibility** to ensure that the necessary steps to enter the national phase are taken in a timely fashion. Most designated Offices do not issue reminders to applicants in connection with the entry into the national phase.

For detailed information about the procedural acts to be performed to enter the national phase before each designated Office, the applicable time limits and possible extensions of time or grace periods, and any other requirements, see the relevant Chapters of Volume II of the PCT Applicant's Guide. Information about the requirements for filing a demand for international preliminary examination is set out in Chapter IX of Volume I of the PCT Applicant's Guide.

GR and ES became bound by PCT Chapter II on 7 September 1996 and 6 September 1997, respectively, and may, therefore, be elected in a demand or a later election filed on or after 7 September 1996 and 6 September 1997, respectively, regardless of the filing date of the international application. (See second paragraph above.)

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

CONFIRMATION OF PRECAUTIONARY DESIGNATIONS

This notification lists only specific designations made under Rule 4.9(a) in the request. It is important to check that these designations are correct. Errors in designations can be corrected where precautionary designations have been made under Rule 4.9(b). The applicant is hereby reminded that any precautionary designations may be confirmed according to Rule 4.9(c) before the expiration of 15 months from the priority date. If it is not confirmed, it will automatically be regarded as withdrawn by the applicant. There will be no reminder and no invitation. Confirmation of a designation consists of the filing of a notice specifying the designated State concerned (with an indication of the kind of protection or treatment desired) and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.

REQUIREMENTS REGARDING PRIORITY DOCUMENTS

For applicants who have not yet complied with the requirements regarding priority documents the following is recalled.

Where the priority of an earlier national (i.e., national or regional) application is claimed, the applicant must submit a copy of the said national application, certified by the authority with which it was filed ("the priority document") to the receiving Office (which will transmit it to the International Bureau) or directly to the International Bureau, before the expiration of 16 months from the priority date (Rule 17.1).

Where the priority document is issued by the receiving Office, the applicant may, instead of submitting the priority document, request the receiving Office to prepare and transmit the priority document to the International Bureau. Such request must be made before the expiration of the 16-month time limit.

It is recalled that, where several priorities are claimed, the priority date to be considered for the purposes of computing the 16-month time limit is the filing date of the earliest application whose priority is claimed.

If the priority document concerned is not submitted to the International Bureau before the expiration of the 16-month time limit, or if the request to the receiving Office to transmit the priority document has not been made (and the corresponding fee, if any, paid) before the expiration of this time limit, any designated State may disregard the priority claim.

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To: HENRY TANG
BRUMBAUGH, GRAVES, DONOHUE & RAYMOND
30 ROCKEFELLER PLAZA
NEW YORK, NY 10112-0228

PCT

TO

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

Applicant's or agent's file reference 31222-PCT	Date of Mailing *(day/month/year)* 17 FEB 1998 FOR FURTHER ACTION See paragraphs 1 and 4 below
International application No. PCT/US97/19207	International filing date *(day/month/year)* 24 OCTOBER 1997
Applicant THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK	

1. [X] The applicant is hereby notified that the international search report has been established and is transmitted herewith.

   Filing of amendments and statement under Article 19:
   The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

   When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the international search report; however, for more details, see the notes on the accompanying sheet.

   Where? Directly to the International Bureau of WIPO
   34, chemin des Colombettes
   1211 Geneva 20, Switzerland
   Facsimile No.: (41-22) 740.14.35

   For more detailed instructions, see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [ ] With regard to the protest against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

   [ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

   [ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

   Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in rules 90 *bis* 1 and 90 *bis* 3, respectively, before the completion of the technical preparations for international publication.

   Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

   Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer RICKY QUOC NGO Telephone No. 703-305-4798

Form PCT/ISA/220 (January 1994)★ *(See notes on accompanying sheet)*

Reference in folder

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 31222-PCT	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
International application No. PCT/US97/19207	International filing date *(day/month/year)* 24 OCTOBER 1997	(Earliest) Priority Date *(day/month/year)* NONE
Applicant THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 2 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. [ ] **Certain claims were found unsearchable** (See Box I).

2. [ ] **Unity of invention is lacking** (See Box II).

3. [ ] The international application contains disclosure of a nucleotide and/or amino acid sequence listing and the international search was carried out on the basis of the sequence listing
   - [ ] filed with the international application.
   - [ ] furnished by the applicant separately from the international application,
     - [ ] but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
   - [ ] transcribed by this Authority.

4. With regard to the title,
   - [X] the text is approved as submitted by the applicant.
   - [ ] the text has been established by this Authority to read as follows:

5. With regard to the abstract,
   - [X] the text is approved as submitted by the applicant.
   - [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the drawings to be published with the abstract is:
   Figure No. 2
   - [X] as suggested by the applicant.
   - [ ] because the applicant failed to suggest a figure.
   - [ ] because this figure better characterizes the invention.
   - [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/19207

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : H04J 3/16
US CL : 370/468

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 370/252, 468, 477; 375/240

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,526,350 A (GITTINS et al) 11 June 1996, col. 7, lines 49-65.	1-36
X	US 5,627,970 A (KESHAV) 06 May 1997, col. 6, lines 9-31 & 46-65.	1-36
A	US 5,115,309 A (HANG) 19 May 1992, abstract.	1-36
A	US 5,490,252 A (MACERA et al) 06 February 1996, abstract.	1-36

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 08 JANUARY 1998	Date of mailing of the international search report 17 FEB 1998
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer RICKY QUOC NGO Telephone No. 703-305-4798

Form PCT/ISA/210 (second sheet)(July 1992)*

These Notes are intended to give the basic instructions concerning the filing of amendments under Article 19. The Notes are based on the requirements of the Patent Cooperation Treaty and of the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule" and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions, respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g., the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international publication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the international application may be amended?

The claims only.

The description and the drawings may only be amended during international preliminary examination under Chapter II.

When? Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How? Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confounded with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped), whether

(i) the claim is unchanged;
(ii) the claim is cancelled;
(iii) the claim is new;
(iv) the claim replaces one or more claims as filed;
(v) the claim is the result of the division of a claim as filed.

WO 99/22477
PCT/US97/19207

31222
PCT

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

To:
TANG, Henry
Brumbaugh, Graves, Donohue & Raymond
30 Rockefeller Plaza
New York, NY 10112-0228
ÉTATS-UNIS D'AMÉRIQUE

RECEIVED
BAKER & BOTTS, L.L.P.
99 MAY 18 AM 11:51

DUE AT PAR

Date of mailing (day/month/year) 06 May 1999 (06.05.99)	
Applicant's or agent's file reference 31222-PCT	**IMPORTANT NOTICE**
International application No. PCT/US97/19207	**International filing date** (day/month/year) 24 October 1997 (24.10.97)
	Priority date (day/month/year)
Applicant THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK et al	

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:
   US

   In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:
   CA

   The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on
   06 May 1999 (06.05.99) under No. WO 99/22477

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, **a demand for international preliminary examination** must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the **national phase**, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer J. Zahra
Facsimile No. (41-22) 740.14.35	Telephone No. (41-22) 338.83.38

Form PCT/IB/308 (July 1996)

2593505 CM

encl in pocket

The demand must be filed directly with the competent International Preliminary Examining Authority or, if two or more Authorities are with the one chosen by the applicant. The full name or two-letter code of that Authority may be indicated by the applicant on the line

IPEA/ US

PCT

CHAPTER II

DEMAND

under Article 31 of the Patent Cooperation Treaty:
The undersigned requests that the international application specified below be the subject of international preliminary examination according to the Patent Cooperation Treaty and hereby elects all eligible States (except where otherwise indicated).

For International Preliminary Examining Authority use only

Identification of IPEA	Date of receipt of DEMAND

Box No. I IDENTIFICATION OF THE INTERNATIONAL APPLICATION		Applicant's or agent's file reference 31222-PCT
International application No. PCT/US97/19207	International filing date *(day/month/year)* 24 October 1997 (24.10.97)	(Earliest) Priority date *(day/month/year)* ( )
Title of invention TRANSMISSION CONTROL FOR MINIMIZING CONGESTION IN DIGITAL COMMUNICATIONS NETWORKS		

Box No. II APPLICANT(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*	Telephone No.:
THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK Broadway and 116th Street New York, NY 10027 US	Facsimile No.:
	Teleprinter No.:

State *(that is, country)* of nationality:	State *(that is, country)* of residence:
US	US

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

JACOBS, STEPHEN
Department of Electrical Engineering
Columbia University
530 West 120th Street
New York, NY 10027
US

State *(that is, country)* of nationality:	State *(that is, country)* of residence:
US	US

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

ELEFTHERIADIS, ALEXANDROS
Department of Electrical Engineering
Columbia University
530 West 120th Street
New York, NY 10027
US

State *(that is, country)* of nationality:	State *(that is, country)* of residence:
GR	US

☐ Further applicants are indicated on a continuation sheet.

International application No.
PCT/US97/19207

Box No. III AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The following person is ☒ agent ☐ common representative

and ☒ has been appointed earlier and represents the applicant(s) also for international preliminary examination.

☐ is hereby appointed and any earlier appointment of (an) agent(s) /common representative is hereby revoked.

☐ is hereby appointed, specifically for the procedure before the International Preliminary Examining Authority, in addition to the agent(s)/common representative appointed earlier.

Name and address: *(Family name followed by given name; for a legal entity, full official The address must include postal code and name of country.)*

TANG, HENRY and
BUSINGER, PETER A.
Baker & Botts, LLP
30 Rockefeller Plaza
New York, NY 10112
US

Telephone No.: (212) 705-5000

Facsimile No.: (212) 705-5020

Teleprinter No.:

☐ Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Box No. IV BASIS FOR INTERNATIONAL PRELIMINARY EXAMINATION

Statement concerning amendments:*

1. The applicant wishes the international preliminary examination **to start on the basis of:**

☒ the international application as originally filed.

the description ☐ as originally filed
☐ as amended under Article 34

the claims ☐ as originally filed
☐ as amended under Article 19 (together with any accompanying statement)
☐ as amended under Article 34

the drawings ☐ as originally filed
☐ as amended under Article 34

2. ☐ The applicant wishes any amendment to the claims under Article 19 to be considered as reversed.

3. ☐ The applicant wishes the start of the international preliminary examination **to be postponed** until the expiration of 20 months from the priority date unless the International Preliminary Examing Authority receives a copy of any amendments made under Article 19 or a notice from the applicant that he does not wish to make such amendments (Rule 69.1(d)). *(This check-box may be marked only where the time limit under Article 19 has not yet expired.)*

* Where no check-box is marked, international preliminary examination will start on the basis of the international application as originally filed or, where a copy of amendments to the claims under Article 19 and/or amendments of the international application under Article 34 are received by the International Preliminary Examining Authority before it has begun to draw up a written opinion or the international preliminary examination report, as so amended.

Language for the purposes of international preliminary examination: English

☒ which is the language in which the international application was filed.
☐ which is the language of a translation furnished for the purposes of international search.
☐ which is the language of publication of the international application.
☐ which is the language of the translation (to be) furnished for the purposes of international preliminary examination.

Box No. V ELECTION OF STATES

The applicant hereby **elects all eligible States** *(that is, all States which have been designated and which are bound by Chapter II of the PCT)*

excluding the following States which the applicant wishes **not to elect:**

International application No.
PCT/US97/19207

Box No. VI CHECK LIST

The demand is accompanied by the following elements, in the language referred to in Box No. IV, for the purposes of international preliminary examination:			For International Preliminary Examining Authority use only: received	not received
1. translation of international application	:	sheets	☐	☐
2. amendments under Article 34	:	sheets	☐	☐
3. copy (or where required, translation) of amendments under Article 19	:	sheets	☐	☐
4. copy (or, where required, translation) of statement under Article 19	:	sheets	☐	☐
5. letter	:	sheets	☐	☐
6. other *(specify)*	:	sheets	☐	☐

The demand is also accompanied by the item(s) marked below:

1. ☒ fee calculation sheet
2. ☐ separate signed power of attorney
3. ☐ copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☐ nucleotide and or amino acid sequence listing in computer readable form
6. ☒ other *(specify)*: Transmitttal Letter

Box No. VII SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the demand).

Peter A. Businger

Peter A. Businger (Agent)

For International Preliminary Examining Authority use only

1. Date of actual receipt of DEMAND:
2. Adjusted date of receipt of demand due to CORRECTIONS under Rule 60.1(b):
3. ☐ The date of receipt of the demand is AFTER the expiration of 19 months from the priority date and item 4 or 5, below, does not apply. ☐ The applicant has been informed accordingly.
4. ☐ The date of receipt of the demand is WITHIN the period of 19 months from the priority date as extended by virtue of Rule 80.5.
5. ☐ Although the date of receipt of the demand is after the expiration of 19 months from the priority date, the delay in arrival is EXCUSED pursuant to Rule 82.

For International Bureau use only

Demand received from IPEA on:

CHAPTER II

PCT

FEE CALCULATION SHEET

Annex to the Demand for international preliminary examination

International application No.	PCT/US97/19207
Applicant's or agent's file reference	31222-PCT

For International Preliminary Examining Authority use only

Date stamp of the IPEA

Applicant

THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK

Calculation of prescribed fees

1. Preliminary examination fee	490.00	P
2. Handling fee *(Applicants from certain States are entitled to a reduction of 75% of the handling fee. Where the applicant is (or all applicants are) so entitled, the amount to be entered at H is 25% of the handling fee.)*	162.00	H
3. Total of prescribed fees Add the amounts entered at P and H and enter total in the TOTAL box	652.00	TOTAL

Mode of Payment

☐	authorization to charge deposit account with the IPEA (see below)	☐	cash
☒	cheque	☐	revenue stamps
☐	postal money order	☐	coupons
☐	bank draft	☐	other *(specify)*:

Deposit Account Authorization *(this mode of payment may not be available at all IPEAs)*

The IPEA/ US ☐ is hereby authorized to charge the total fees indicated above to my deposit account.

☒ *(this check-box may be marked only if the conditions for deposit accounts of the IPEA so permit)* is hereby authorized to charge any deficiency or credit any overpayment in the total fees indicated above to my deposit account.

02-4377	20 May 1999	Peter A. Buerger
Deposit Account Number	Date *(day/month/year)*	Signature

See Notes to the fee calculation sheet

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:
HENRY TANG
BAKER & BOTTS, LLP
30 ROCKEFELLER PLAZA
NEW YORK, NY 10112

PCT

NOTIFICATION OF RECEIPT
OF DEMAND BY COMPETENT INTERNATIONAL
PRELIMINARY EXAMINING AUTHORITY

(PCT Rules 59.3(e) and 61.1(b), first sentence
and Administrative Instructions, Section 601(a))

Date of mailing *(day/month/year)* 23 JUN 1999

Applicant's or agent's file reference
31222-PCT

IMPORTANT NOTIFICATION

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US97/19207	24 OCT 97	

Applicant
THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF & NEW YORK

1. The applicant is hereby **notified** that this International Preliminary Examining Authority considers the following date as the date of receipt of the demand for international preliminary examination of the international application:

20 May 1999 (20 05 99)

2. That date of receipt is:

- [X] the actual date of receipt of the demand by this Authority (Rule 61.1(b)).
- [ ] the actual date of receipt of the demand on behalf of this Authority (Rule 59.3(e)).
- [ ] the date on which this Authority has, in response to the invitation to correct defects in the demand (Form PCT/IPEA/404), received the required corrections.

3. [ ] **ATTENTION:** That date of receipt is **AFTER** the expiration of 19 months from the priority date. Consequently, the election(s) made in the demand does (do) not have the effect of postponing the entry into the national phase until 30 months from the priority date (or later in some Offices) (Article 39(1)). Therefore, the acts for entry into the national phase must be performed within 20 months from the priority date (or later in some Offices) (Article 22). For details, see the *PCT Applicant's Guide*, Volume II.

[ ] *(If applicable)* This notification confirms the information given by telephone, facsimile transmission or in person on:

_____

4. Only where paragraph 3 applies, a copy of this notification has been sent to the International Bureau.

Name and mailing address of the IPEA/	Authorized officer
Assistant Commissioner for Patent Box PCT Washington, D.C. 20231 Attn:RO/US Facsimile No. 703-305-3230	YOUNGER, MARILYN (MJ) Telephone No. 703-305-3753

Form PCT/IPEA/402 (July 1998)

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To: HENRY TANG
BAKER & BOTTS, LLP
30 ROCKEFELLER PLAZA
NEW YORK, NY 10112-0228

PCT

NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of Mailing *(day/month/year)*	05 APR 2000
Applicant's or agent's file reference: 31222-PCT	IMPORTANT NOTIFICATION

International application No.	International filing date *(day/month/year)*	Priority Date *(day/month/year)*
PCT/US97/19207	24 OCTOBER 1997	NONE

Applicant
THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices)(Article 39(1))(see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

4/24/00
Deadline

Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer RICKY QUOC NGO Telephone No. 703-305-4798

Form PCT/IPEA/416 (July 1992)★

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 31222-PCT	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/US97/19207	International filing date *(day/month/year)* 24 OCTOBER 1997	Priority date *(day/month/year)* NONE
International Patent Classification (IPC) or national classification and IPC IPC(6): H04J 3/16 and US Cl.: 370/468		
Applicant THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets.

   [X] This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority. (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 5 sheets.

3. This report contains indications relating to the following items:

   I [X] Basis of the report

   II [ ] Priority

   III [ ] Non-establishment of report with regard to novelty, inventive step or industrial applicability

   IV [ ] Lack of unity of invention

   V [X] Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

   VI [ ] Certain documents cited

   VII [ ] Certain defects in the international application

   VIII [ ] Certain observations on the international application

Date of submission of the demand	Date of completion of this report
20 MAY 1999	10 MARCH 2000
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer RICKY QUOC NGO Telephone No. 703-305-4798

Form PCT/IPEA/409 (cover sheet) (July 1998)*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US97/19207

I. Basis of the report

1. With regard to the elements of the international application:*

☐ the international application as originally filed

☒ the description:
pages (See Attached), as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

☒ the claims:
pages (See Attached), as originally filed
pages _____, as amended (together with any statement) under Article 19
pages _____, filed with the demand
pages _____, filed with the letter of _____

☒ the drawings:
pages (See Attached), as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

☒ the sequence listing part of the description:
pages (See Attached), as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language _____ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in printed form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the writen sequence listing has been furnished.

4. ☒ The amendments have resulted in the cancellation of:

☒ the description, pages NONE
☒ the claims, Nos. NONE
☒ the drawings, sheets/~~fig~~ NONE

5. ☒ This report has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US97/19207

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. statement

Novelty (N)	Claims	NONE	YES
	Claims	1-36	NO
Inventive Step (IS)	Claims	NONE	YES
	Claims	1-36	NO
Industrial Applicability (IA)	Claims	1-36	YES
	Claims	NONE	NO

2. citations and explanations (Rule 70.7)

Claims 1-36 lack novelty under PCT Article 33(2) as being anticipated by Keshav, U.S. Patent No. 5,627,970.

- Regarding claims 1, 2, 11, 13, 14, 23, 25, 26 and 35, Keshav discloses a method and system for achieving and maintaining data transmission rates, same as data transmission bandwidth, between a source node and a destination node in a digital data network (see abstract). The system of Keshav includes means for maintaining an estimate of bandwidth available to from source node to the destination node (col. 6 lines 9-25); and means for adjusting transmission based on the estimate (col. 6 lines 25-31). The transmission of the system utilizes IP protocol which supports transmission in real time (col. 5 lines 48-53).

- Regarding claims 3, 15, and 27, the system of Keshav also monitors packet loss based on acknowledgements from the destination node (col. 7 line 60 to col. 8 line 5).

- Regarding claims 4, 7, 16, 19, 28, and 31, the system of Keshav also maintains a count of packets/bytes (col. 7 line 66 to col. 8 line 2).

- Regarding claims 5, 6, 8, 9, 17, 18, 20, 21, 29, 30, 32, and 33, the system of Keshav maintains the data transmission rates of how many packets/bytes are allows to be transmitted (abstract) in accordance with TCP congestion window.

- Regarding claims 10, 12, 22, 24, 34, and 36, the system of Keshav also retransmits a packet which has been determined as lost packet at the destination node (col. 8 lines 32-35).

Claims 1, 11, 13, 23, 25, and 35 lack novelty under PCT Article 33(2) as being anticipated by Gittins et al., U.S. Patent No. 5,526,350. Gittins et al. disclose system in which a bandwidth manager is arranged to dynamically allocate bandwidth to a different type of traffic in a digital telephony network (see abstract).
(Continued on Supplemental Sheet.)

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Boxes I - VIII

I. BASIS OF REPORT:

This report has been drawn on the basis of the description,
page(s) 1-13, as originally filed.
page(s) NONE, filed with the demand.
and additional amendments:
NONE

This report has been drawn on the basis of the claims,
page(s) NONE, as originally filed.
page(s) NONE, as amended under Article 19.
page(s) NONE, filed with the demand.
and additional amendments:
Pages 14-18, filed with the letter of 17 December 1999.

This report has been drawn on the basis of the drawings,
page(s) 1-4, as originally filed.
page(s) NONE, filed with the demand.
and additional amendments:
NONE

This report has been drawn on the basis of the sequence listing part of the description:
page(s) NONE, as originally filed.
pages(s) NONE, filed with the demand.
and additional amendments:
NONE

5. (Some) amendments are considered to go beyond the disclosure as filed:
NONE

V. 2. REASONED STATEMENTS - CITATIONS AND EXPLANATIONS (Continued):

Claims 1-36 meet the criteria set out in PCT Article 33(4), the system and method of claims provides data transmission between a sender and a receiver in a digital network, such system and method having industrial applicability.

———— NEW CITATIONS ————

NONE

Claims

1. A method for transmitting data in real time from a sender to a receiver in a digital communications network, comprising the steps of:

maintaining an estimate of bandwidth available from the sender to the receiver; and

adjusting transmission based on the estimate in order to maintain real time transmission.

2. The method according to claim 1, wherein the data comprises compressed video data.

3. The method according to claim 1, wherein maintaining the estimate of bandwidth comprises monitoring of packet loss based on acknowledgments from the receiver.

4. The method according to claim 1, wherein, in maintaining the estimate of bandwidth, the sender maintains a count of packets outstanding.

5. The method according to claim 4, wherein, in maintaining the estimate of bandwidth, the sender maintains current an upper bound on how many packets are allowed to be outstanding.

6. The method according to claim 5, wherein the upper bound is as specified by the TCP congestion window.

7. The method according to claim 1, wherein, in maintaining the estimate of bandwidth, the sender maintains a count of bytes outstanding.

8. The method according to claim 7, wherein, in maintaining the estimate of bandwidth, the sender maintains current an upper bound on how many bytes are allowed to be outstanding.

9. The method according to claim 8, wherein the upper bound is as specified by the TCP congestion window.

10. The method according to claim 1, further comprising retransmitting a packet which has been determined by the receiver as having been lost in transmission or received with an error.

11. The method according to claim 1, further comprising adapting bandwidth required by the data.

12. The method according to claim 1, further comprising discriminating between packets lost due to congestion in the network and packets received with at least one bit error.

13. A system for transmitting data in real time from a sender to a receiver in a digital communications network, comprising:

means for maintaining an estimate of bandwidth available from the sender to the receiver; and

means for adjusting transmission based on the estimate in order to maintain real time transmission.

14. The system according to claim 13, wherein the data comprises compressed video data.

15. The system according to claim 13, wherein the means for maintaining the estimate of bandwidth comprises means for monitoring of packet loss based on acknowledgments from the receiver.

16. The system according to claim 13, wherein the means for maintaining the estimate of bandwidth comprises means for maintaining a count of packets outstanding.

17. The system according to claim 16, wherein the means for maintaining the estimate of bandwidth comprises means for maintaining current an upper bound on how many packets are allowed to be outstanding.

18. The system according to claim 17, wherein the upper bound is as specified by the TCP congestion window.

19. The system according to claim 13, wherein the means for maintaining the estimate of bandwidth comprises means for maintaining a count of bytes outstanding.

20. The system according to claim 19, wherein the means for maintaining the estimate of bandwidth comprises means for maintaining current an upper bound on how many bytes are allowed to be outstanding.

21. The system according to claim 20, wherein the upper bound is as specified by the TCP congestion window.

22. The system according to claim 13, further comprising means for retransmitting a packet which has been determined by the receiver as having been lost in transmission or received with an error.

23. The system according to claim 13, further comprising means for adapting bandwidth required by the data.

24. The system according to claim 13, further comprising means for discriminating between packets lost due to congestion in the network and packets received with at least one bit error.

25. A system for transmitting data in real time from a sender to a receiver in a digital communications network, comprising a processor which is instructed for:

maintaining an estimate of bandwidth available from the sender to the receiver; and

adjusting transmission based on the estimate in order to maintain real time transmission.

26. The system according to claim 25, wherein the data comprises compressed video data.

27. The system according to claim 25, wherein maintaining the estimate of bandwidth comprises monitoring of packet loss based on acknowledgments from the receiver.

28. The system according to claim 25, wherein, in maintaining the estimate of bandwidth, the sender maintains a count of packets outstanding.

29. The system according to claim 28, wherein, in maintaining the estimate of bandwidth, the sender maintains current an upper bound on how many packets are allowed to be outstanding.

30. The system according to claim 29, wherein the upper bound is as specified by the TCP congestion window.

31. The system according to claim 25, wherein, in maintaining the estimate of bandwidth, the sender maintains a count of bytes outstanding.

32. The system according to claim 31, wherein, in maintaining the estimate of bandwidth, the sender maintains current an upper bound on how many bytes are allowed to be outstanding.

33. The system according to claim 32, wherein the upper bound is as specified by the TCP congestion window.

34. The system according to claim 25, wherein the processor is instructed further for retransmitting a packet which has been determined by the receiver as having been lost in transmission or received with an error.

35. The system according to claim 25, wherein the processor is instructed further for adapting bandwidth required by the data.

36. The system according to claim 25, wherein the processor is instructed further for discriminating between packets lost due to congestion in the network and packets received with at least one bit error.

PATENT COOPERATION TREATY

31222
PCT

From the INTERNATIONAL BUREAU

PCT

INFORMATION CONCERNING ELECTED OFFICES NOTIFIED OF THEIR ELECTION

(PCT Rule 61.3)

To:

TANG, Henry
Brumbaugh, Graves, Donohue & Raymond
30 Rockefeller Plaza
New York, NY 10112-0228
ÉTATS-UNIS D'AMÉRIQUE

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Date of mailing (day/month/year) 09 July 1999 (09.07.99)	
Applicant's or agent's file reference 31222-PCT	**IMPORTANT INFORMATION**
International application No. PCT/US97/19207	**International filing date** (day/month/year) 24 October 1997 (24.10.97)
	Priority date (day/month/year)
Applicant THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK et al	

1. The applicant is hereby informed that the International Bureau has, according to Article 31(7), notified each of the following Offices of its election:

   National :CA,US

2. The following Offices have waived the requirement for the notification of their election; the notification will be sent to them by the International Bureau only upon their request:

   None

3. The applicant is reminded that he must enter the "national phase" **before the expiration of 30 months from the priority date** before each of the Offices listed above. This must be done by paying the national fee(s) and furnishing , if prescribed, a translation of the international application (Article 39(1)(a)), as well as, where applicable, by furnishing a translation of any annexes of the international preliminary examination report (Article 36(3)(b) and Rule 74.1).

   Some offices have fixed time limits expiring later than the above-mentioned time limit. For detailed information about the applicable time limits and the acts to be performed upon entry into the national phase before a particular Office, see Volume II of the PCT Applicant's Guide.

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Facsimile No. (41-22) 740.14.35

Authorized officer:
F. Baechler

Telephone No. (41-22) 338.83.38

2723380

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

99 OCT 22 PM 3:47

To: HENRY TANG
BAKER & BOTTS, LLP
30 ROCKEFELLER PLAZA
NEW YORK, NY 10112-0228

PCT

WRITTEN OPINION

(PCT Rule 66)

Date of Mailing *(day/month/year)*	19 OCT 1999
Applicant's or agent's file reference: 31222-PCT	REPLY DUE within TWO months from the above date of mailing

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US97/19207	24 OCTOBER 1997	NONE

International Patent Classification (IPC) or both national classification and IPC
IPC(6): H04J 3/16 and US Cl.: 370/468

Applicant
THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK

1. This written opinion is the first (first, etc.) drawn by this International Preliminary Examining Authority.

2. This opinion contains indications relating to the following items:

- I [X] Basis of the opinion
- II [ ] Priority
- III [ ] Non-establishment of opinion with regard to novelty, inventive step or industrial applicability
- IV [ ] Lack of unity of invention
- V [X] Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI [ ] Certain documents cited
- VII [ ] Certain defects in the international application
- VIII [ ] Certain observations on the international application

DOCKETED
FOR 12/15/1999 BY

3. The applicant is hereby invited to reply to this opinion.

When? See the time limit indicated above. ~~The applicant may, before the expiration of that time limit, request this Authority to grant an extension., see Rule 66.2(d).~~

How? By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3. For the form and the language of the amendments, see Rules 66.8 and 66.9.

Also For an additional opportunity to submit amendments, see Rule 66.4.
For the examiner's obligation to consider amendments and/or arguments, see Rule 66.4 *bis*.
For an informal communication with the examiner, see Rule 66.6.

If no reply is filed, the international preliminary examination report will be established on the basis of this opinion.

4. The final date by which the international preliminary examination report must be established according to Rule 69.2 is: 24 FEBRUARY 2000

Name and mailing address of the IPEA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	RICKY QUOC NGO Joni Hill
Facsimile No. (703) 305-3230	Telephone No. 703-305-4798

Form PCT/IPEA/408 (cover sheet) (January 1994)*

WRITTEN OPINION

International application No.
PCT/US97/19207

I. Basis of the opinion

1. This opinion has been drawn on the basis of *(Substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed".)*:

[X] the international application as originally filed.

[X] the description, pages 1-13 , as originally filed.
pages NONE , filed with the demand.
pages NONE , filed with the letter of _____.

[X] the claims, Nos. 1-36 , as originally filed.
Nos. NONE , as amended under Article 19.
Nos. NONE , filed with the demand.
Nos. NONE , filed with the letter of _____.

[X] the drawings, sheets/~~fig~~ 1-4 , as originally filed.
sheets/~~fig~~ NONE , filed with the demand.
sheets/~~fig~~ NONE , filed with the letter of _____.

2. The amendments have resulted in the cancellation of:

[X] the description, pages NONE

[X] the claims, Nos. NONE

[X] the drawings, sheets/~~fig~~ NONE

3. [ ] This opinion has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the ~~Supplemental Box~~ Additional observations below (Rule 70.2(c)).

4. Additional observations, if necessary:
NONE

WRITTEN OPINION

International application No.
PCT/US97/19207

V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. STATEMENT

Novelty (N)	Claims	NONE	YES
	Claims	1-36	NO
Inventive Step (IS)	Claims	NONE	YES
	Claims	1-36	NO
Industrial Applicability (IA)	Claims	1-36	YES
	Claims	NONE	NO

2. CITATIONS AND EXPLANATIONS

Claims 1-36 lack novelty under PCT Article 33(2) as being anticipated by Keshav, U.S. Patent No. 5,627,970.

- Regarding claims 1, 11, 13, 23, 25, and 35, Keshav discloses a method and system for achieving and maintaining data transmission rates, same as data transmission bandwidth, between a source node and a destination node in a digital data network (see abstract). The system of Keshav includes means for maintaining an estimate of bandwidth available to from source node to the destination node (col. 6 lines 9-25); and means for adjusting transmission based on the estimate (col. 6 lines 25-31).

- Regarding claims 2, 14, and 26, the transmission of the system utilizes IP protocol which supports transmission in real time (col. 5 lines 48-53).

- Regarding claims 3, 15, and 27, the system of Keshav also monitors packet loss based on acknowledgements from the destination node (col. 7 line 60 to col. 8 line 5).

- Regarding claims 4, 7, 16, 19, 28, and 31, the system of Keshav also maintains a count of packets/bytes (col. 7 line 66 to col. 8 line 2).

- Regarding claims 5, 6, 8, 9, 17, 18, 20, 21, 29, 30, 32, and 33, the system of Keshav maintains the data transmission rates of how many packets/bytes are allows to be transmitted (abstract) in accordance with TCP congestion window.

- Regarding claims 10, 12, 22, 24, 34, and 36, the system of Keshav also retransmits a packet which has been determined as lost packet at the destination node (col. 8 lines 32-35).

Claims 1, 11, 13, 23, 25, and 35 lack novelty under PCT Article 33(2) as being anticipated by Gittins et al., U.S. Patent No. 5,526,350. Gittins et al. disclose system in which a bandwidth manager is arranged to dynamically allocate bandwidth to a different type of traffic in a digital telephony network (see (Continued on Supplemental Sheet.)

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Boxes I - VIII

TIME LIMIT:

The time limit set for response to a Written Opinion may not be extended. 37 CFR 1.484(d). Any response received after the expiration of the time limit set in the Written Opinion will not be considered in preparing the International Preliminary Examination Report.

V. 2. REASONED STATEMENTS - CITATIONS AND EXPLANATIONS (Continued):
abstract).

Claims 1-36 meet the criteria set out in PCT Article 33(4), the system and method of claims provides data transmission between a sender and a receiver in a digital network, such system and method having industrial applicability.

——————— NEW CITATIONS ———————

NONE

31222-PCT 070050.0772

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

Applicant	:	The Trustees of Columbia University in the City of New York
International Application No.	:	PCT/US97/19207
International Filing Date	:	24 October 1997
Title of Invention	:	TRANSMISSION CONTROL FOR MINIMIZING CONGESTION IN DIGITAL COMMUNICATIONS NETWORKS

REPLY TO WRITTEN OPINION

VIA FACSIMILE
ORIGINAL BY EXPRESS MAIL
EXPRESS MAIL NO.: EJ339569445

Hon. Commissioner of Patents and Trademarks
BOX PCT
Washington DC 20231

Dear Sir:

In accordance with PCT Rules 66.3, 66.8 and 66.9, applicant submits this reply to the Written Opinion dated 19 October, 1999 in the above-referenced application.

Amendment

Claims 1, 13, and 25 have been amended to better distinguish the prior art by incorporating the limitations of former claims 2, 14, and 26, and claims 2, 14, and 26 have been amended to round out the scope of protection claimed by applicant. Substitute pages 14 - 18 reflecting the amended claims are submitted herewith.

Remarks

The International Examiner has opined that each of claims 1-36 meet the criteria of PCT Article 33(4). However, the International Examiner has also opined that all claims of the present application lack novelty under PCT Article 33(2) as being anticipated

by U.S. Patent No. 5,627,970 to Keshav, and that claims 1, 11, 13, 23 and 25 lack novelty on the alternative ground as being anticipated by U.S. Patent 5,526,350 to Gittins. For the reasons set forth below, Applicant respectfully submits that the Examiner's opinions concerning lack of novelty are erroneous and that the inventions set forth in claims 1-36 are patentably distinct from the cited art.

Claims 1, 13, and 25 have been amended to better distinguish the prior art by incorporating the limitation previously contained in former claims 2, 14, and 26, i.e., that transmission occur in real time. Claims 2, 14, and 26 have been amended to round out the scope of protection claimed by applicant by specifying that the data is compressed video data. Support for the amendment may be found, e.g., at pages 6-9 of the International Specification, where an embodiment concerning MPEG compressed video is disclosed. No new matter has been added.

Accordingly, as amended, independent claim 1 is directed to a method for transmitting data in real time from a sender to a receiver in a digital communications network, comprising the steps of maintaining an estimate of bandwidth available from the sender to the receiver; and adjusting transmission based on the estimate in order to maintain real time transmission. Likewise, amended claims 13 and 25 are directed to systems for transmitting data in real time from a sender to a receiver in a digital communications network.

With these arrangements, as described for example on pages 1-2 of the international specification, a transmission technique which, although not perfectly reliable, provides that it more likely that transmitted data arrive on time is presented. Such a technique is highly preferred for congestion control in a digital communications network such as the Internet or corporate "Intranets."

No such transmission techniques are disclosed in or suggested by Keshav or Gittins. Keshav describes an invention that attempts to be 100% reliable, meaning that any packet sent from the source node will, eventually, be received at the destination node. This is not a real time protocol, since if a packet is lost by the network (which occurs quite often in an internet), Keshav will retransmit the packet, ensuring reliability. In a real-time environment that packet is only valuable if it arrives on time, i.e. in video conferencing a packet that contains speech must arrive at the same time as the packet containing the video

of the person uttering that speech. Since the patent specifically discloses the automatic retransmission of lost packets, e.g., at Column 6, lines 37-45, Keshav incurs increasing delays that are intolerable for real-time environments. Nothing in Keshav discloses or suggests the real time transmission techniques required by amended claims 1, 13 or 25.

Regarding claims 10, 12, 22, 24, 34, and 36 of the present invention, retransmission of packets can occur only if such retransmission does not damage the real-time service. This is in contrast to Keshav will discloses without exception retransmitting data that has been lost in the network.

Regarding the Gittins patent, that reference describes a technique which requires operation under an entirely different environment and is not comparable with that the present invention. The Gittins patent is directed to "[a] switched telecommunications network [which] includes a plurality of switches for switching different types of traffic..." which is not an Internet. Moreover, Gittins assumes that bandwidth is managed by the bandwidth managers centrally, and that the bandwidth managers assign bandwidth to each connection. In contrast, the present invention does not presuppose any of this preexisting infrastructure of bandwidth managers, since Internets do not have the infrastructure of bandwidth managers, and instead must "maintain[] an estimate of bandwidth available" in the communications network. Nothing in Keshav discloses or suggests the real time transmission techniques required by amended claims 1, 13 or 25, or of dependant claims 11, 23, or 35.

In view of the foregoing, the International Examiner's written opinion concerning the lack of novelty of claims 1-36 of the present application is respectfully traversed. It is submitted that the claims as presently drafted meet the requirements of PCT Article 33(2) - (3).

Respectfully submitted,

Dated: December 17, 1999

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Reg. No. 29,705

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PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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H04J 3/16	A1	(43) International Publication Date:	6 May 1999 (06.05.99)

(21) International Application Number: PCT/US97/19207

(22) International Filing Date: 24 October 1997 (24.10.97)

(71) Applicant *(for all designated States except US)*: THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK [US/US]; Broadway & 116th Street, New York, NY 10027–6699 (US).

(72) Inventors; and

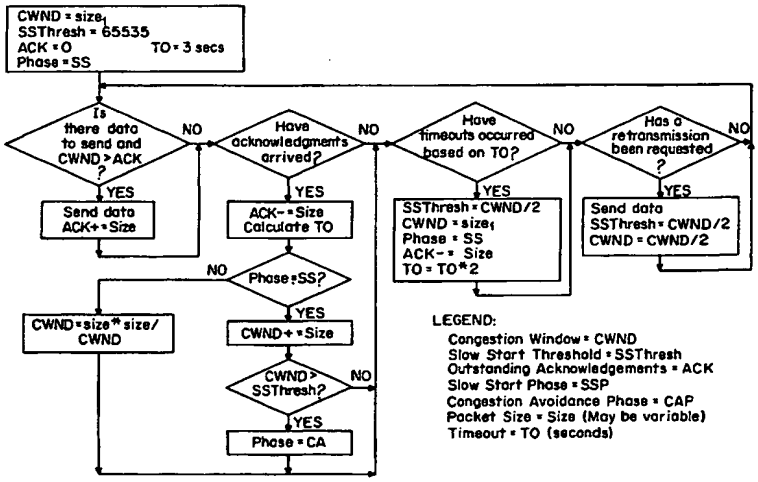
(75) Inventors/Applicants *(for US only)*: JACOBS, Stephen [US/US]; Columbia University, Dept. of Electrical Engineering, 530 West 120th Street, New York, NY 10027–6699 (US). ELEFTHERIADIS, Alexandros [GR/US]; Columbia University, Dept. of Electrical Engineering, 530 West 120th Street, New York, NY 10027–6699 (US).

(74) Agents: TANG, Henry et al.; Brumbaugh, Graves, Donohue & Raymond, 30 Rockefeller Plaza, New York, NY 10112–0228 (US).

(81) Designated States: CA, US.

Published
With international search report.

(54) Title: TRANSMISSION CONTROL FOR MINIMIZING CONGESTION IN DIGITAL COMMUNICATIONS NETWORKS



(57) Abstract

In congestion control in a digital communications network such as the Internet or corporate "Intranets", and especially in real–tine transmissions in such networks, perfect reliability may not be required. For increased likelihood that data arrive on time, an estimate is used of the bandwidth which is available from a sender to a receiver. The estimate is increased or decreased, by the sender, depending on monitoring of acknowledgemnts from the receiver. The technique coexists well with protocols based on TCP (Transmission Control Protocol), such as FTP (File Transfer Protocol) and HTTP (Hyper Text Transfer Protocol), by sharing the available bandwidth equally.

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TRANSMISSION CONTROL FOR MINIMIZING CONGESTION IN DIGITAL COMMUNICATIONS NETWORKS

Technical Field

The invention relates to transmissions in a digital communications network and, more specifically, to transmission control for minimizing network congestion.

Background of the Invention

For preventing loss of data due to congestion in digital network communications, a protocol known as Transmission Control Protocol (TCP) has been proposed for the Internet; see Information Sciences Institute, "Transmission Control Protocol - Request for Comments 793", September 1981 and W. Stevens, "TCP Slow Start, Congestion Avoidance, Fast Retransmit, and Fast Recovery Algorithms - Request for Comments 2001", January 1997. TCP is based on the notion of fair sharing of transmission resources among users.

TCP is reliable, in the sense that the data received at a destination are an exact duplicate of the data that was sent. Such reliability may be at the expense of transmission delays, however.

For some transmissions, e.g. real-time audio and video, reliability is less important, and the primary concern is with the data arriving on time. Specifically, for example, it is more acceptable to lose an occasional frame of video than to have the video start and stop repeatedly.

Summary of the Invention

For congestion control in a digital communications network such as the Internet or corporate "Intranets", and especially for real-time transmissions in such networks,

a transmission technique is preferred which is not perfectly reliable, but which makes it more likely that the data arrive on time. The technique uses an estimate of the bandwidth which is available in a network, from a sender to a receiver. The estimate is increased or decreased, by the sender, depending on monitoring of acknowledgments from the receiver.

The technique is compatible with TCP, and its use by a sender in a connection results in fair sharing of network resources with all other connections. It can be used, e.g., with well-established protocols such as File Transfer Protocol (FTP) and Hyper Text Transfer Protocol (HTTP).

Brief Description of the Drawing

Fig. 1 is a representation of packet format for a preferred embodiment of the invention.

Fig. 2 is a flow chart for processing at a network server, in accordance with a preferred embodiment of the invention.

Figs. 3a and 3b are schematics of communications systems in accordance with preferred embodiments of the invention, with fixed and adaptable bandwidth requirements, respectively.

Fig. 4 is a flow chart for exemplary rate control processing in a system according to Fig. 3b.

Fig. 5a is a graphic representation of system behavior for an example in a system in accordance with Fig. 3a.

Fig. 5b is a graphic representation of system behavior for an example in a system in accordance with Fig. 3b.

Fig. 6 is a representation of packet format for a preferred embodiment of the invention in a wireless or hybrid wired-wireless network.

Detailed Description of Preferred Embodiments

While preferred embodiments are described in the following primarily in method terms, the inventive technique also includes systems embodiments, e.g. involving a programmed processor. A prototype implementation uses a Unix Workstation as network server and a PC as client server, both programmed in C++. Use of special-purpose firmware or hardware is not precluded.

The technique is window-based in the sense that a sender maintains a count of the number of outstanding packets, i.e., packets which have been sent, but for which an acknowledgment has not yet been received from the receiver. The sender maintains current an upper bound on the number of outstanding packets allowed in the network, called the "congestion window" (CWND) and providing an indication of the available bandwidth from sender to receiver. Congestion is detected when a packet is lost in the network. Alternatively, and especially in transmissions of variable-length packets, CWND can be maintained in units of bytes rather than units of packets.

If the number of outstanding packets is less than CWND, the sender can continue to send data into the network. Otherwise, the sender must stop transmitting data until either CWND increases or the number of outstanding packets decreases. If acknowledgments are received, CWND will increase, and the number of outstanding packets will decrease. If no acknowledgments are returned, packets will timeout and be deemed lost by

the protocol, thus decreasing the number of outstanding packets.

Optionally, selective retransmission can be provided for. A current estimate is maintained of the round trip time, i.e. the time elapsed between sending a packet and receiving an acknowledgment. The protocol sends the estimate to the receiver in each packet header. When the receiver determines that a packet has been lost, it then determines if there is enough time to receive the retransmitted packet before it is needed. If so, the receiver can request a retransmission; otherwise, no request is made. In real-time audio or video, for example, if the receiver has 100 milliseconds worth of data buffered for playback when detecting loss of a packet, and if the estimate for the round-trip time is less than 100 milliseconds, a request for retransmission is likely to result in timely retransmission of the lost packet. Thus, a best-effort attempt is made at reliability.

As illustrated by Fig. 1, a data packet includes the standard User Datagram Protocol (UDP) header, a 2-byte sequence number, a 4-byte time stamp, and a 4-byte round-trip time estimate measured in milliseconds. The sequence number is for packet reordering at the receiver, in case packets arrive out of order. The time stamp is media dependent and generally provides an indication of the presentation time of the packet.

Fig. 2 illustrates preferred packet processing by a server system. There is a main loop which continually checks whether (i) data can be sent out, (ii) an acknowledgment has arrived, (iii) a timeout has occurred, or (iv) a retransmission was requested. Initially, CWND is set to the size of the first packet to be transmitted, ensuring that the first packet can be sent out.

"Outstanding acknowledgments" (ACK) is set to zero. "Timeout" (TO) is set to 3 seconds, for example, indicating the amount of time not to be exceeded between sending a packet and receiving its acknowledgment. If an acknowledgment is not received in time, the packet is assumed to be lost. The system starts out in a "Slow-Start Phase" indicated by Phase=SS.

Since CWND is the size of the first packet, ACK=0, and there is data available to send (namely the first packet), the first packet is sent into the network. ACK is then increased by the size of the packet sent, representing the number of bytes currently in the network that have not yet been acknowledged. The system then checks whether acknowledgments have arrived. If so, Outstanding Acknowledgments is decreased by the size of the packet to which the acknowledgment refers: ACK = ACK-size. The system then calculates the Round Trip Time (RTT), i.e. the difference between when a packet was sent and when the acknowledgment was received. RTT is used in the calculation of Timeout (TO).

The system maintains an estimate of the round trip time, RTT_{avg}, by using the measured RTT, RTT_i, for each acknowledgment. Following D. Comer, "Internetworking with TCP/IP", 3rd Edition, Simon & Schuster, 1995, pp. 191-230, RTT_{avg} and Timeout (for future use) are calculated as follows:

$$Diff = RTT_i - RTT_{avg}$$
$$RTT_{avg} = RTT_{avg} + Diff/8$$
$$Dev_i = 0.25 \cdot (|Diff| - Dev_i)$$
$$Timeout = RTT + 0.25 + 3 \cdot Dev_i$$

Now, in Slow Start Phase, CWND is increased by *size*:

$$CWND = CWND + size;$$

later, in Congestion Avoidance Phase (Phase≠SS), CWND is increased by the square of the size divided by the current value of CWND:

$$CWND = CWND + size^2/CWND.$$

Slow Start calls for increasing the value of CWND each time an acknowledgment is received. In the case of variable length packets, with CWND being the number of bytes of outstanding packets, Slow Start calls for increasing the value of CWND by the size of the packet to which the acknowledgment refers.

After increasing CWND, there follows checking of CWND > SSThresh, the Slow Start Threshold. If true, Phase = CA, for Congestion Avoidance.

Then, concerning timeouts, if an acknowledgment is not received within Timeout (TO) milliseconds after it was sent, the packet is determined to be lost in the network and the appropriate action is taken. This includes (i) setting SSThresh to half of the current CWND, (ii) setting CWND to the value of the next packet to be sent out (i.e. resetting CWND), (iii) setting Phase to Slow Start, (iv) decreasing the outstanding acknowledgment by the size of the packet which timed out, and (v) doubling the Timeout period (TO).

Finally, the system checks for receipt of a retransmission request. If so, it resends the appropriate data and resets SSThresh and CWND to half the current value of CWND. This is known as Fast Recovery. The system then returns to check for further data to send, and whether CWND > ACK.

As described, the technique does not depend on whether the bandwidth requirements of the media can be changed or adapted. Fig. 3a shows a system with non-adaptable media, such as MPEG. The server reads the media from a file or obtains it from a live source and

fills a buffer. At the server, the media pump sends the data to the client from the buffer, taking into account the current value of CWND determined in accordance with Fig. 2, and the media pump supplies the size values for congestion control. In case of significant congestion, CWND will be less than ACK, and this will stop the media pump from sending further data for a period of time, thereby reducing the media pump transmission rate.

So long as the average available bandwidth of a connection is greater than or equal to the bandwidth requirements of the media, and so long as there is sufficient buffering, the media can be played back without interruption. With congestion-minimizing processing as described above, few packets will be lost, and can be retransmitted if there is enough time.

Buffering provides for variation in the available bandwidth: the larger the buffer, the more variation can be accommodated. But there is an initial start-up delay while a client buffer is being filled, so that increased buffering results in a longer start-up delay.

As to adaptable media, there are several ways of changing bandwidth requirements. In the case of MPEG, for example, one way involves dropping frames as described by Z. Chen et al., "Real Time Video and Audio in the World Wide Web", World Wide Web Journal, Vol. 1, January 1996. The server finds the picture header in the MPEG stream and stops sending data until it finds the next picture header in the stream. This has the effect of dropping one frame from the media stream, and thereby reducing the bandwidth requirements. As frames are interdependent in MPEG, a frame should not be dropped if other frames depend on it, i.e. an I-frame cannot be dropped if the stream contains P- or B-frames which depend on it.

For MPEG video, another technique for bandwidth reduction is known as Dynamic Rate Shaping (DRS) as described by A. Eleftheriadis et al., "Constrained and General Dynamic Rate Shaping of Compressed Digital Video", Proceedings, 2nd IEEE International Conference on Image Processing, Washington, D.C., October 1995, pp. III.396-399. This involves identifying, frame by frame, those coefficients in the MPEG stream which are least important in terms of image quality, and removing them from the stream.

Fig. 3b shows an adaptable media system. Again, the original media either is stored locally or is supplied by a live source. But, in this case the data enters a media adaptation module which shapes the media into an estimate of the available bandwidth. The shaped media enters the buffer, which is then read by the media pump. Again, the media pump sends out data so as to comply with the CWND. At the client, the data is buffered for presentation to the user. The client provides feedback information for congestion control.

The status of the buffer between the media adaptation module and the media pump is critical for this system. If the buffer is filling, then the media pump is sending data out more slowly than the media adaptation module is filling the buffer. In this case, the system should decrease the bandwidth requirements of the media so that the buffer does not overflow, by dropping frames or assigning a lower rate to DRS.

Conversely, if the buffer is emptying, the media pump is sending data out faster than the buffer is being filled by the media adaptation module. In this case, the system should increase the bandwidth requirements of the media so that the user gets the best quality possible. Since rate control provides information to the media adaptation module, it is highly dependent on the time of

media being adapted. The media pump operates as in the non-adaptable case, sending data only when CWND > ACK. Based on the occupancy of the buffer, the adaptable media module is instructed to change the rate of the media.

For example, for rate control in MPEG video by frame dropping, a frame can be dropped when the buffer is more than half full; otherwise, the video is passed unaltered to the buffer. Other scenarios, using DRS and more sophisticated rate control may be implemented. For example, if the buffer is filling, the transmission rate may be reduced in inverse relationship to the rate of buffer filling.

Fig. 4 illustrates an exemplary rate control technique based on measurements of buffer occupancy. Every 5 seconds, an average buffer occupancy is obtained for the previous 5 seconds, $Occupancy_i$. The change in the buffer occupancy since the previous 5-second interval, $Occupancy_{i-1}$, is determined as $Diff_i$, Start-up is with $Occupancy_0 = 0$.

The Centering factor provides a weighting for the occupancy to stay close to the desired occupancy at the buffer midpoint. The maximum buffer size is 5 seconds worth of data and depends on the originally encoded rate of the stream.

If $Diff_i < 0$,

$$Centering_i = Occupancy_i/Occupancy_{desired},$$

where $Occupancy_{desired}$ is the buffer occupancy which rate control tries to maintain. Otherwise,

$$Centering_i = 2 - (Occupancy_i/Occupancy_{desired}),$$

the goal being to keep the Centering factor between 0 and 2.

Then, $Beta_i$ is determined as a direct indication of how much demand varies in the network, using the Coefficient of Variation of the past and current values

of the average occupancy. The coefficient of variation is defined as

$$\text{Variance(samples)}/\text{Mean}^2\text{(samples)},$$

where the samples are the two values of the average buffer occupancy. Beta is then multiplied by 10. If Beta is less than 0.1, it is assigned the value 0.1, if it is greater that 1.0, it is assigned the value 1.0.

Finally, the new transmission rate is calculated by subtracting, from the previous rate, the value Beta·Centering·Diff·8, where the factor 8 is due to Diff being in bytes and the rate being in bits. These steps are repeated every 5 seconds.

Adaptable media can cope with more drastic variations in network resources, as compared with non-adaptable media. In non-adaptable media, a decrease in network resources results in less data reaching the receiver than is needed, and the receiver can rely only on its initial buffering to continue playback.

Fig. 5a shows an example of using a non-adaptive media. In this case, the rate of the media is 300 kbps, and the final buffering is 5 seconds (1500 kb). The available bandwidth is continually changing. In the beginning there is just enough bandwidth for the media and no buffering is used. But as soon as the available bandwidth decreases to 200 kbps, the receiver must begin using its buffering. If the bandwidth stays low for an extended period of time, the buffer may become completely depleted, at which time the user will experience an interruption in playback. This occurs at around 40 seconds. The available bandwidth then increases to 350 kbps, at which time the buffer can accumulate again.

With adaptable media, the initial buffering has to be used only when the bandwidth requirements of the media cannot be reduced further. As illustrated by Fig. 5b, for the same rate and initial buffering as in Fig. 5a,

the bandwidth requirements of the media can be reduced down to a minimum of 150 kbps. When the available bandwidth drops to 200 kbps, the media also is reduced to this rate, so that no receiver buffering is used to compensate for the network. However, once the available bandwidth decreases to 100 kbps, the media can only be reduced to 150 kbps, and so the receiver buffer begins to be depleted. This scenario is more robust, as the available bandwidth can drop to 150 kbps and receiver buffering is not used.

Congestion control in accordance with the invention is applicable wherever some degree of loss can be tolerated, including most video and audio codecs, with adaptable codecs being preferred. Most video codecs can be adapted by using frame dropping. Even still images can be adapted for real-time applications. JPEG and MPEG have similarities in the way they are coded, so that a technique like DRS can be used on JPEG as well. A new standard known as Flashpix has the capability to be displayed at different resolutions, and hence different bandwidth requirements when sending a picture across the Internet.

While preferred embodiments have been described above under the assumption of a wired network, composed of fiber-optic or coaxial physical cables, techniques of the invention can be used to advantage with wireless networks as well. As digital communications protocols were originally devised with wired networks in mind, most congestion-aware protocols, TCP included, assume that a lost packet indicates congestion. This is practicable in wired networks, where bit errors are uncommon. Bit errors are more common in a wireless environment, however, so that a packet is more likely to become "lost" due to an error in the packet, regardless of congestion. But known systems do not include facilities for informing

the receiver when a packet has arrived containing an error. Internet Protocol (IP) packets are simply dropped at the receiver if there is an error in the header.

Currently, with UDP, the receiver system has the option of instructing the sender system not to put error checking in packets. This is on a system-wide basis, so that all UDP packets coming from the sender system will not use error checking, which is undesirable when other applications expect UDP error checking.

Preferably, in accordance with a preferred embodiment of the invention, the receiver can distinguish whether a packet is lost due to congestion or error, in an application-specific fashion.

Fig. 6 illustrates a packet constructed from an IP packet provided with the shaded area by the operating system. Error checking will be over the IP header only, so that a bit error there still results in the packet being dropped without notification. However, without error checking over the payload, a bit error in the payload does not result in the packet being dropped.

In this embodiment of the invention, the sender constructs a UDP header inside the payload of the IP packet, for the packet to appear as a regular UDP packet at the receiver. In the UDP header, the sender sets the Cyclic Redundancy Code (CRC) field to zero, indicating that no error checking is used. Accordingly, when the receiver reads the packet, the UDP module of the receiver system will not do any error checking, leaving it to the application to check for errors.

So that packets received with errors are not used, the sender must insert its own error checking functionality into the payload of the UDP packet it constructs. In Fig. 6, this is shown as Application Defined CRC. If, using Application Defined CRC, the receiver determines that there is an error, the receiver

application drops the packet and sends a request for retransmission to the sender— without invoking congestion avoidance to reduce the transmission rate at the sender. If there is no error, the packet is used by the receiver application, with regular acknowledgment.

In this fashion, the likelihood of a packet being dropped by the receiver operating system due to packet error is minimized, and greater throughput is realized on wireless networks without impairing the performance on wired networks. No changes are required to the operating system nor the underlying network link layer, so long as the link layer does not perform error checking over the entire link layer packet.

This preferred technique can be used with all proprietary client-server protocols which are congestion-aware. Such protocols must be proprietary because of changes to both the client and the server. Accordingly, adaptable media applications are preferred.

Claims

1. A method for transmitting data from a sender to a receiver in a digital communications network, comprising:

maintaining an estimate of bandwidth available from the sender to the receiver; and

adjusting transmission based on the estimate.

2. The method according to claim 1, wherein transmission is in real time.

3. The method according to claim 1, wherein maintaining the estimate of bandwidth comprises monitoring of packet loss based on acknowledgments from the receiver.

4. The method according to claim 1, wherein, in maintaining the estimate of bandwidth, the sender maintains a count of packets outstanding.

5. The method according to claim 4, wherein, in maintaining the estimate of bandwidth, the sender maintains current an upper bound on how many packets are allowed to be outstanding.

6. The method according to claim 5, wherein the upper bound is as specified by the TCP congestion window.

7. The method according to claim 1, wherein, in maintaining the estimate of bandwidth, the sender maintains a count of bytes outstanding.

8. The method according to claim 7, wherein, in maintaining the estimate of bandwidth, the sender

maintains current an upper bound on how many bytes are allowed to be outstanding.

9. The method according to claim 8, wherein the upper bound is as specified by the TCP congestion window.

10. The method according to claim 1, further comprising retransmitting a packet which has been determined by the receiver as having been lost in transmission or received with an error.

11. The method according to claim 1, further comprising adapting bandwidth required by the data.

12. The method according to claim 1, further comprising discriminating between packets lost due to congestion in the network and packets received with at least one bit error.

13. A system for transmitting data from a sender to a receiver in a digital communications network, comprising:

means for maintaining an estimate of bandwidth available from the sender to the receiver; and

means for adjusting transmission based on the estimate.

14. The system according to claim 13, wherein transmission is in real time.

15. The system according to claim 13, wherein the means for maintaining the estimate of bandwidth comprises means for monitoring of packet loss based on acknowledgments from the receiver.

16. The system according to claim 13, wherein the means for maintaining the estimate of bandwidth comprises means for maintaining a count of packets outstanding.

17. The system according to claim 16, wherein the means for maintaining the estimate of bandwidth comprises means for maintaining current an upper bound on how many packets are allowed to be outstanding.

18. The system according to claim 17, wherein the upper bound is as specified by the TCP congestion window.

19. The system according to claim 13, wherein the means for maintaining the estimate of bandwidth comprises means for maintaining a count of bytes outstanding.

20. The system according to claim 19, wherein the means for maintaining the estimate of bandwidth comprises means for maintaining current an upper bound on how many bytes are allowed to be outstanding.

21. The system according to claim 20, wherein the upper bound is as specified by the TCP congestion window.

22. The system according to claim 13, further comprising means for retransmitting a packet which has been determined by the receiver as having been lost in transmission or received with an error.

23. The system according to claim 13, further comprising means for adapting bandwidth required by the data.

24. The system according to claim 13, further comprising means for discriminating between packets lost

due to congestion in the network and packets received with at least one bit error.

25. A system for transmitting data from a sender to a receiver in a digital communications network, comprising a processor which is instructed for:

maintaining an estimate of bandwidth available from the sender to the receiver; and

adjusting transmission based on the estimate.

26. The system according to claim 25, wherein transmission is in real time.

27. The system according to claim 25, wherein maintaining the estimate of bandwidth comprises monitoring of packet loss based on acknowledgments from the receiver.

28. The system according to claim 25, wherein, in maintaining the estimate of bandwidth, the sender maintains a count of packets outstanding.

29. The system according to claim 28, wherein, in maintaining the estimate of bandwidth, the sender maintains current an upper bound on how many packets are allowed to be outstanding.

30. The system according to claim 29, wherein the upper bound is as specified by the TCP congestion window.

31. The system according to claim 25, wherein, in maintaining the estimate of bandwidth, the sender maintains a count of bytes outstanding.

32. The system according to claim 31, wherein, in maintaining the estimate of bandwidth, the sender maintains current an upper bound on how many bytes are allowed to be outstanding.

33. The system according to claim 32, wherein the upper bound is as specified by the TCP congestion window.

34. The system according to claim 25, wherein the processor is instructed further for retransmitting a packet which has been determined by the receiver as having been lost in transmission or received with an error.

35. The system according to claim 25, wherein the processor is instructed further for adapting bandwidth required by the data.

36. The system according to claim 25, wherein the processor is instructed further for discriminating between packets lost due to congestion in the network and packets received with at least one bit error.

UDP HEADER	SEQ. NUM 2 BYTES	TIMESTAMP 4 BYTES	ROUND TRIP TIME 4 BYTES	PAYLOAD

FIG. 1

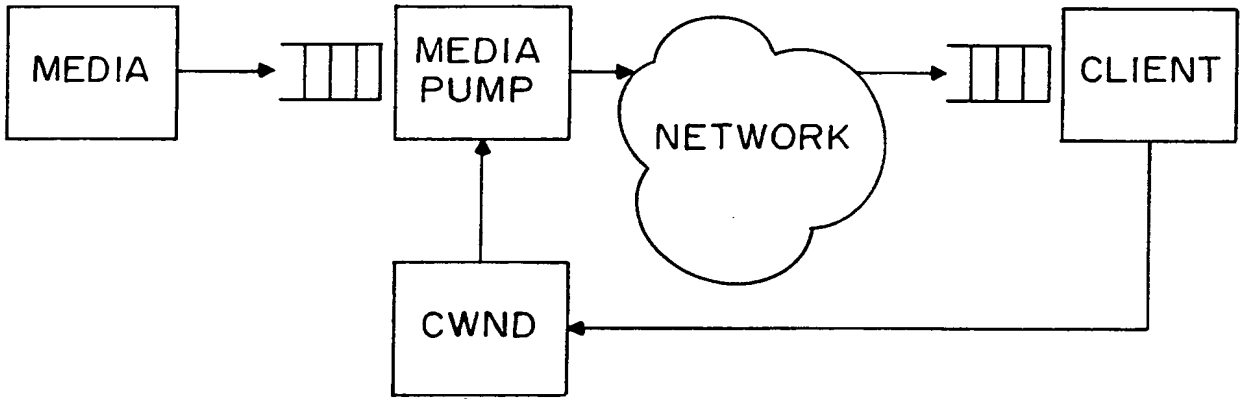

FIG. 3a

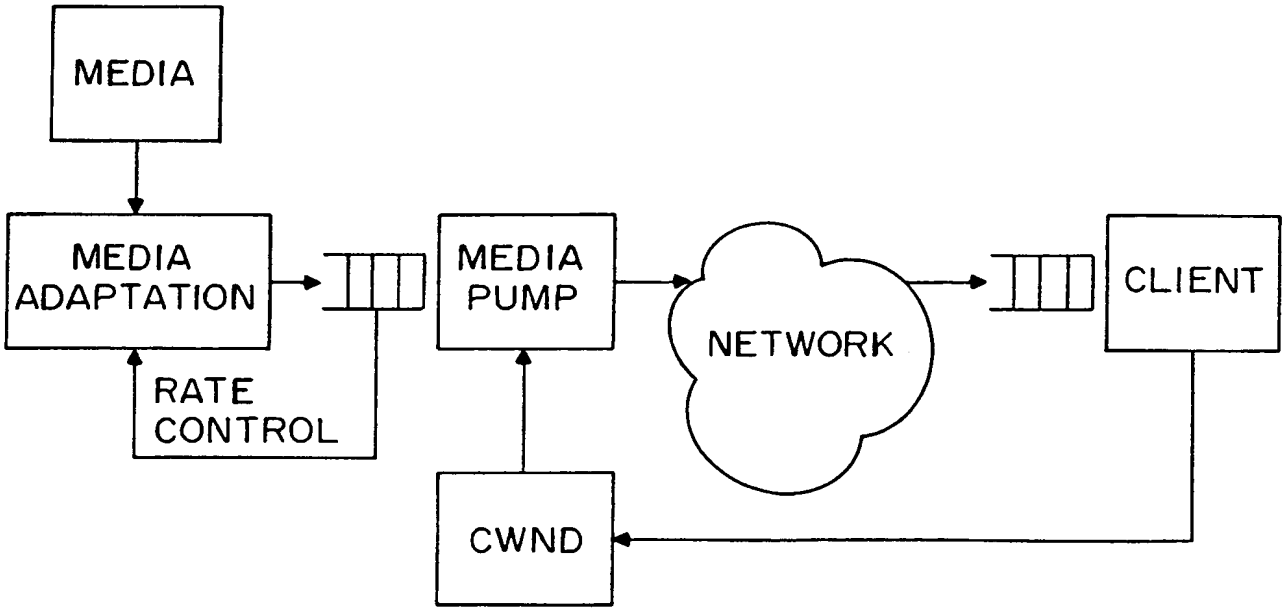

FIG. 3b

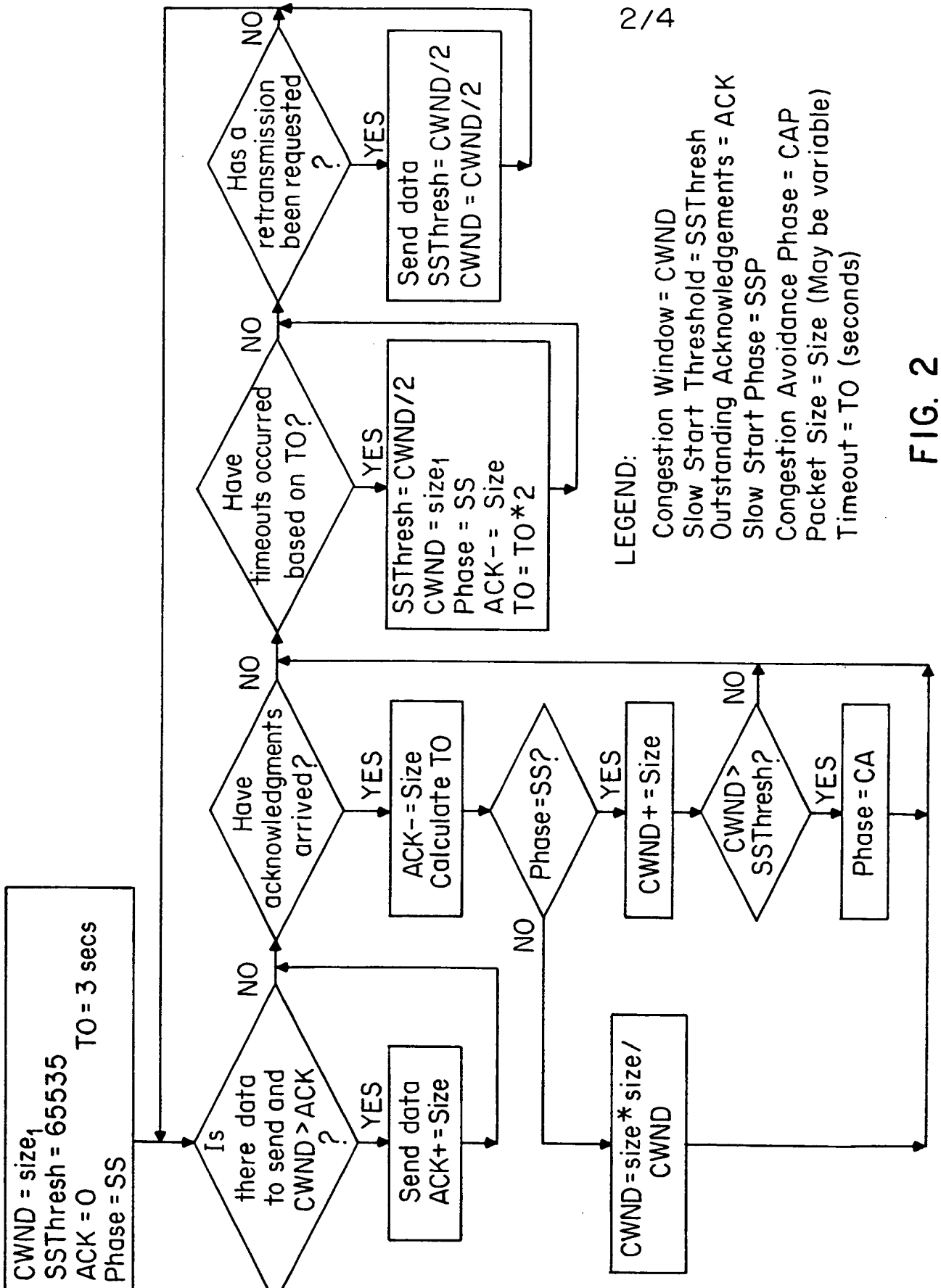
CWND = size1
SSThresh = 65535
ACK = 0
Phase = SS
TO = 3 secs
Is there data to send and CWND > ACK ?
YES
Send data
ACK+ = Size
NO
Have acknowledgments arrived?
YES
ACK- = Size
Calculate TO
NO
Phase=SS?
YES
CWND+ = Size
NO
CWND > SSThresh?
YES
Phase = CA
NO
CWND=size*size/CWND
Have timeouts occurred based on TO?
YES
SSThresh = CWND/2
CWND = size1
Phase = SS
ACK- = Size
TO = TO*2
NO
Has a retransmission been requested ?
YES
Send data
SSThresh = CWND/2
CWND = CWND/2
NO
LEGEND:
Congestion Window = CWND
Slow Start Threshold = SSThresh
Outstanding Acknowledgements = ACK
Slow Start Phase = SSP
Congestion Avoidance Phase = CAP
Packet Size = Size (May be variable)
Timeout = TO (seconds)

FIG. 2

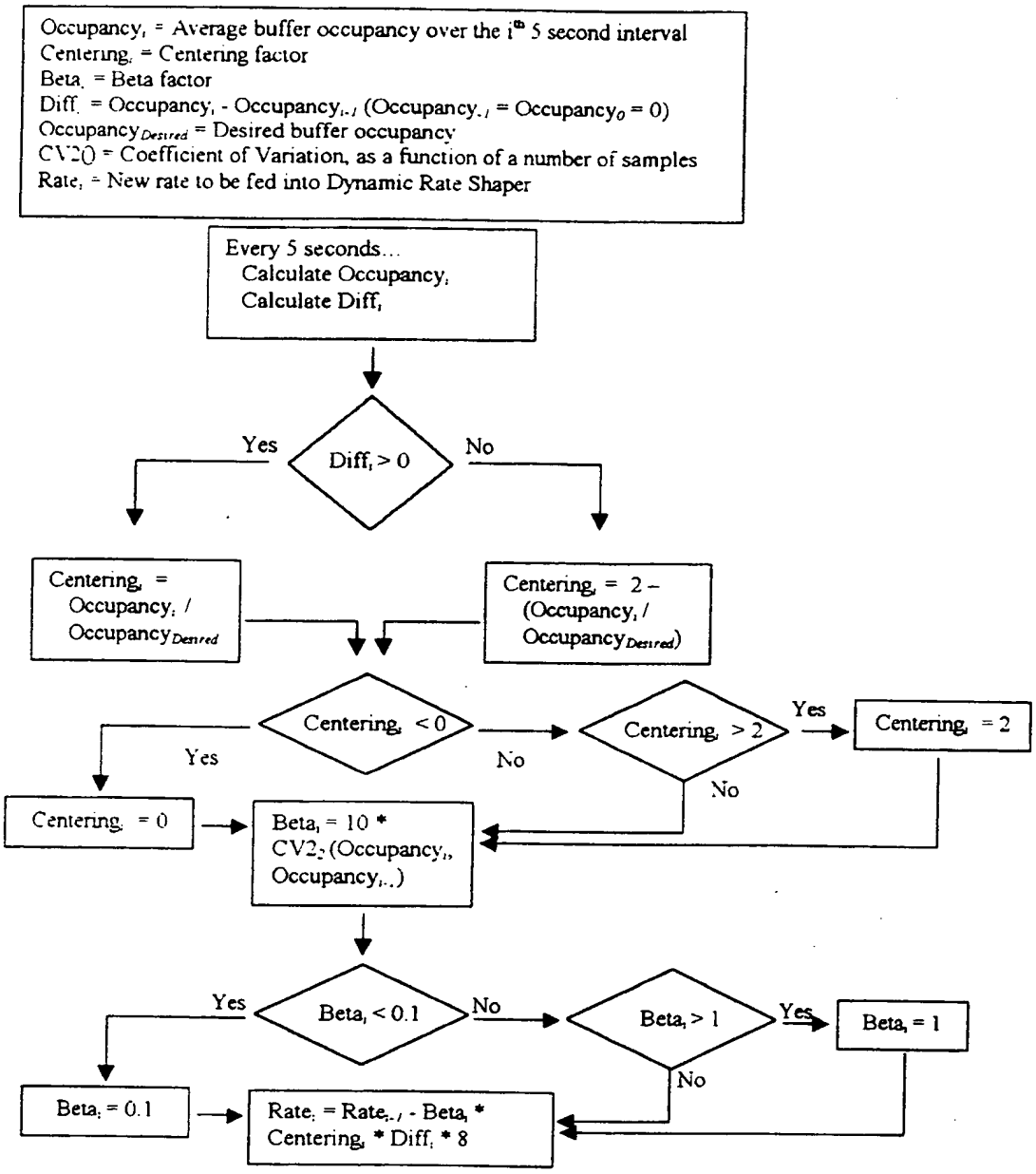
Occupancy$_i$ = Average buffer occupancy over the ith 5 second interval
Centering$_i$ = Centering factor
Beta$_i$ = Beta factor
Diff$_i$ = Occupancy$_i$ - Occupancy$_{i-1}$ (Occupancy$_{-1}$ = Occupancy$_0$ = 0)
Occupancy$_{Desired}$ = Desired buffer occupancy
CV2() = Coefficient of Variation, as a function of a number of samples
Rate$_i$ = New rate to be fed into Dynamic Rate Shaper
Every 5 seconds...
Calculate Occupancy$_i$
Calculate Diff$_i$
Diff$_i$ > 0
Yes
No
Centering$_i$ = Occupancy$_i$ / Occupancy$_{Desired}$
Centering$_i$ = 2 – (Occupancy$_i$ / Occupancy$_{Desired}$)
Centering$_i$ < 0
Yes
No
Centering$_i$ = 0
Centering$_i$ > 2
Yes
No
Centering$_i$ = 2
Beta$_i$ = 10 * CV2$_2$(Occupancy$_i$, Occupancy$_{i-1}$)
Beta$_i$ < 0.1
Yes
No
Beta$_i$ = 0.1
Beta$_i$ > 1
Yes
No
Beta$_i$ = 1
Rate$_i$ = Rate$_{i-1}$ - Beta$_i$ * Centering$_i$ * Diff$_i$ * 8

Fig. 4

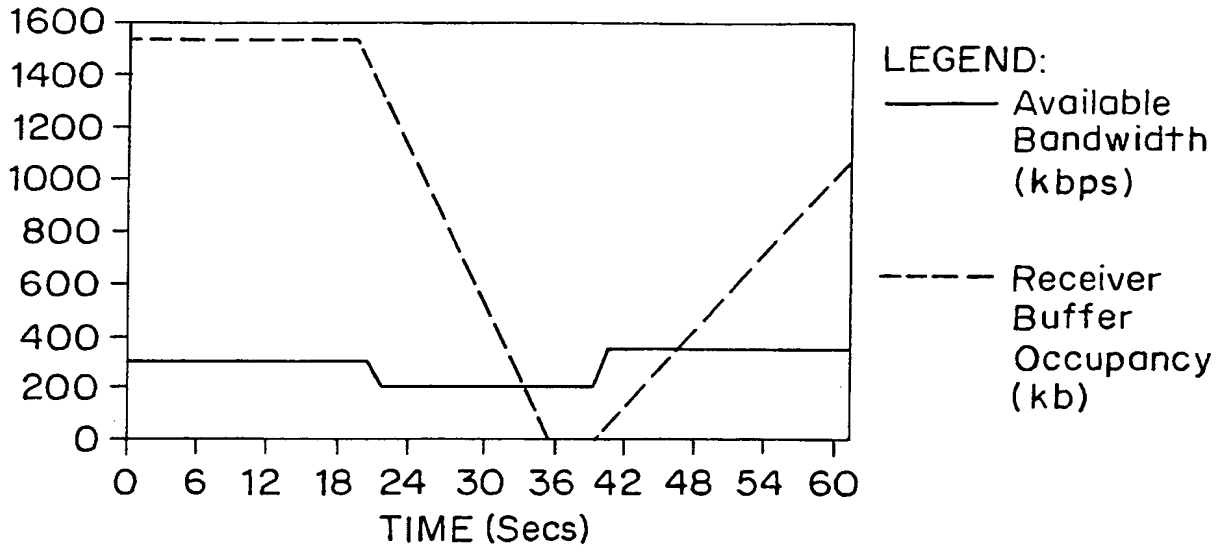

FIG. 5a

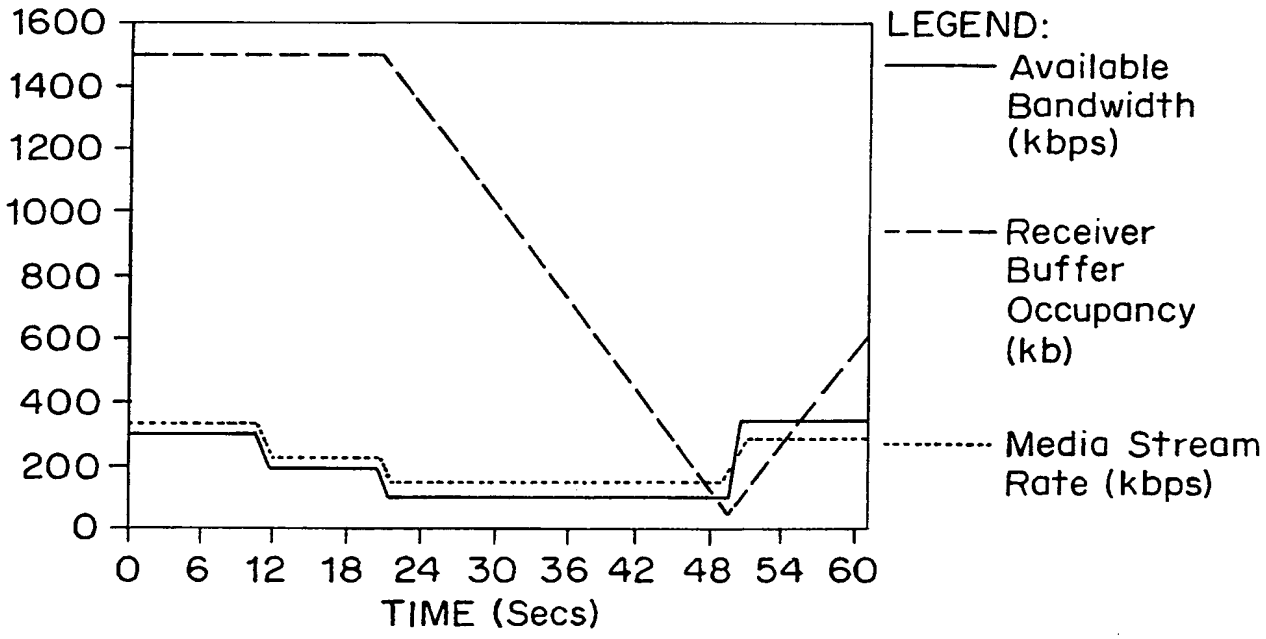

FIG. 5b

IP HEADER	UDP HEADER WITH CRC = 0	APPLICATION DEFINED CRC	SEQ NUM, TIMESTAMP, AND RTT	PAYLOAD

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/19207

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : H04J 3/16
US CL : 370/468

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 370/252, 468, 477; 375/240

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,526,350 A (GITTINS et al) 11 June 1996, col. 7, lines 49-65.	1-36
X	US 5,627,970 A (KESHAV) 06 May 1997, col. 6, lines 9-31 & 46-65.	1-36
A	US 5,115,309 A (HANG) 19 May 1992, abstract.	1-36
A	US 5,490,252 A (MACERA et al) 06 February 1996, abstract.	1-36

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 08 JANUARY 1998	Date of mailing of the international search report 17 FEB 1998
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer RICKY QUOC NGO Telephone No. 703-305-4798

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/19207

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : H04J 3/16
US CL : 370/468

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 370/252, 468, 477; 375/240

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

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A	US 5,115,309 A (HANG) 19 May 1992, abstract.	1-36
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"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
08 JANUARY 1998	17 FEB 1998

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